

# RLV Technology Flight Demonstration Study

## *Interim Status Briefing*

*January 23, 2002*

### **DISCLAIMER**

The interim study results presented herein are provided to industry and other interested parties for consideration in preparation of proposals for future government x-vehicle programs. This is an interim report and reflects NASA's current evaluation of x-vehicle programs. A final report will follow the conclusion of the study. Nothing presented herein in any way alters the content or requirements of any ongoing procurement.





*"SEE DISCLAIMER"*

# ***Presentation Agenda***



## **◆ Introduction and Overview**

- Study Charter
- Study Team Members

## **◆ Task 1: Lessons Learned from Previous Flight Demonstrations**

## **◆ Task 2: Technology Demonstration Requirements**

## **◆ Task 3: Flight Demonstration Options**

## **◆ Task 4: Gap Analysis and Trade Studies**

## **◆ Task 5: Flight Demonstration Status and Plans**

## **◆ Task 6: X-43A/X-43C Boost Options**

## **◆ Task 7: Integration and Process Definition**

## **◆ Wrap-up and Discussion**



***RLV Technology Flight Demonstration Study team is formed at the direction of the Code R AA to document RLV technology flight demonstration needs, considerations, and test options. The team's products will serve as a resource for developing low cost flight demonstration strategies.***



*"SEE DISCLAIMER"*  
**Study Team Members**



***(Includes only Task Leads and Organization Representatives)***

◆ Phil Sumrall	MSFC	256-544-3145
◆ Leland Dutro	MSFC	256-544-0660
◆ Bill Pannell	MSFC	256-544-0521
◆ Bob Werka	MSFC/2nd Gen RLV	256-544-1032
◆ Richard Tyson	MSFC/3rd Gen RLV	256-544-5930
◆ Dan Rasky	ARC	650-604-1098
◆ Mark Klem	GRC	216-433-8000
◆ Chuck McClinton	LaRC	757-864-6253
◆ Ron Ray	DFRC	661-276-3687
◆ Col. Sam Liburdi	AFSPC	256-544-5277
◆ Col. Mike Wolfert	AFSPC	719-554-6853
◆ Lt.-Col. Tom Buter	AFRL	256-544-4659
◆ Capt. Trevis Bergert	SMC	256-955-2089
◆ Vance Houston	MSFC	256-544-0200
◆ Curtis McNeal	MSFC	256-544-8538
◆ Doug Whitehead	JSC	281-483-4699
◆ Phil Weber	KSC	321-867-2057



*"SEE DISCLAIMER"*

## ***Additional Information***



- ◆ **The CBD announcement of this briefing will be appended to provide details on how to obtain a copy of today's presentation**
- ◆ **The projected date of the final report is April 2002**

# **Task 2**

# **X-Vehicle Technology**

# **Demonstration Requirements**

by  
*Dr. Dan Rasky*

Senior Scientist  
*NASA Ames Research Center*  
Moffett Field, CA 94035  
[\(650\) 604-1098](mailto:drasky@arc.nasa.gov)

## **DISCLAIMER**

The interim study results presented herein are provided to industry and other interested parties for consideration in preparation of proposals for future government x-vehicle programs. This is an interim report and reflects NASA's current evaluation of x-vehicle programs. A final report will follow the conclusion of the study. Nothing presented herein in any way alters the content or requirements of any ongoing procurement.





"SEE DISCLAIMER"

## ***Task 2 - Technology Demonstration Needs***



### ***Objective***

- ◆ **Establish technology demonstration requirements for new operational Earth to orbit (ETO) space transportation systems, including answering:**
  - What technologies must be flight demonstrated?
  - Test options?
  - Ground vs. flight test?
  - Integration requirements?
  - Scale?
  - Required flight profiles and environments?
- ◆ **Interim results will only discuss requirements process and does not provide final requirements for any specific program**



*"SEE DISCLAIMER"*  
**Approach**



## **1) Establish POC's for major technology areas**

- Structures/TPS (Paul Kolodziej/ARC, Joe Brunty/MSFC, David Glass/LaRC)
- Propulsion (Curtis McNeal/MSFC, Mark Klem/GRC)
- Software (Howard Cannon/ARC, Brian Glass/ARC)
- Subsystems, Crew Systems & Ops (Mark Klem/GRC, Phil Weber/KSC, Greg Hite/JSC)
- Air Force representative is Lt. Col. Tom Buter

## **2) Assemble technology requirement lists for each technology area**

- Pulling from 2nd Gen, 3rd Gen, DoD, DARPA, previous vehicle development programs
- No attempt to develop additional mission requirements

## **3) Establish an effective technology development and implementation model - "Phased Risk Approach"**



*"SEE DISCLAIMER"*

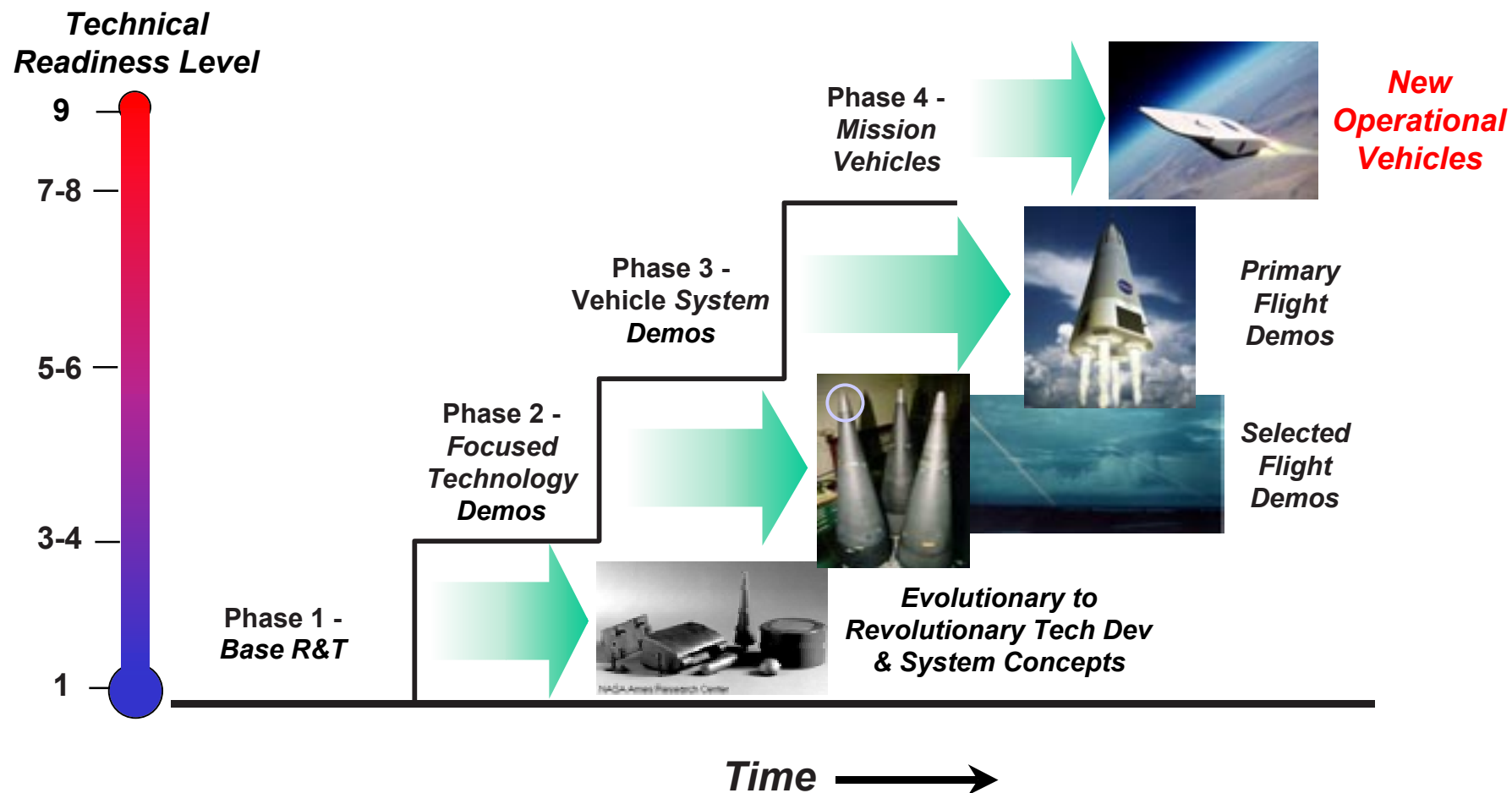
## ***Approach (Cont.)***



- 4) Establish methodology/filter for assessing flight demonstration requirements - "Flight Filter"**
- 5) Use "Flight Filter" on each technology area list to establish scrubbed lists of technologies requiring flight demonstration
- 6) Establish scale, flight profiles, environments and other requirements for flight demonstrations
- 7) Integrate results with other X-vehicle tasks
- 8) Produce final report/presentation

# Technology Development Model

**Key question: How do you efficiently and effectively develop new technologies that impact future mission vehicles?**



**"Phased Risk Approach"**



## ***Technology Development Model (Cont.)***



### **◆ Focused Technology Demos (Phase 2)**

- Demonstration focused on establishing the response, characteristics and performance of a particular technology, by exercising a component or subsystem in a representative ground or flight environment

### **◆ Vehicle System Demos (Phase 3)**

- Activity comprising the assembly of multiple technologies (existing and advanced) into a vehicle system, in order to establish vehicle subsystem performance and interactions and overall vehicle functionality and characteristics, in representative ground or flight environments

### **◆ In addition to technical readiness (TRL), useful to introduce integration readiness levels (IRL) to further refine program phase assessment**



"SEE DISCLAIMER"

# Technology and Integration Readiness Levels



## TRL (Technology Focused)

9	Actual Technology <b>Flight Proven</b> In Operation
8	Actual Technology <b>Flight Qualified</b> by Demonstration
7	Technology Prototype Demonstration in an <b>Operational Environment</b>
6	Technology Model or <b>Prototype Demonstration</b> in a Relevant Envir.
5	Component and/or <b>Breadboard Validation</b> in a Relevant Environment
4	Component and/or Breadboard Validation in <b>Laboratory Environment</b>
3	Analytical and Experimental Critical Function <b>Proof-of-Concept</b>
2	<b>Technology Concept</b> and/or Application Formulated
1	<b>Basic Principles</b> Observed and Reported

## IRL (Vehicle Focused)

5	<b>Operational System Fabrication, Launch &amp; Operations</b>
4	<b>Prototype/Demonstrator Subjected to Representative Flight Environments</b>
3	<b>System Physical Mockup or Prototype, Subjected to Ground Test Envir.</b>
2	<b>Detailed System Design Analyses Completed</b>
1	<b>Concept Systems Analyses Completed</b>

***Vehicle system integration is a non-trivial activity, even with high TRL technologies***



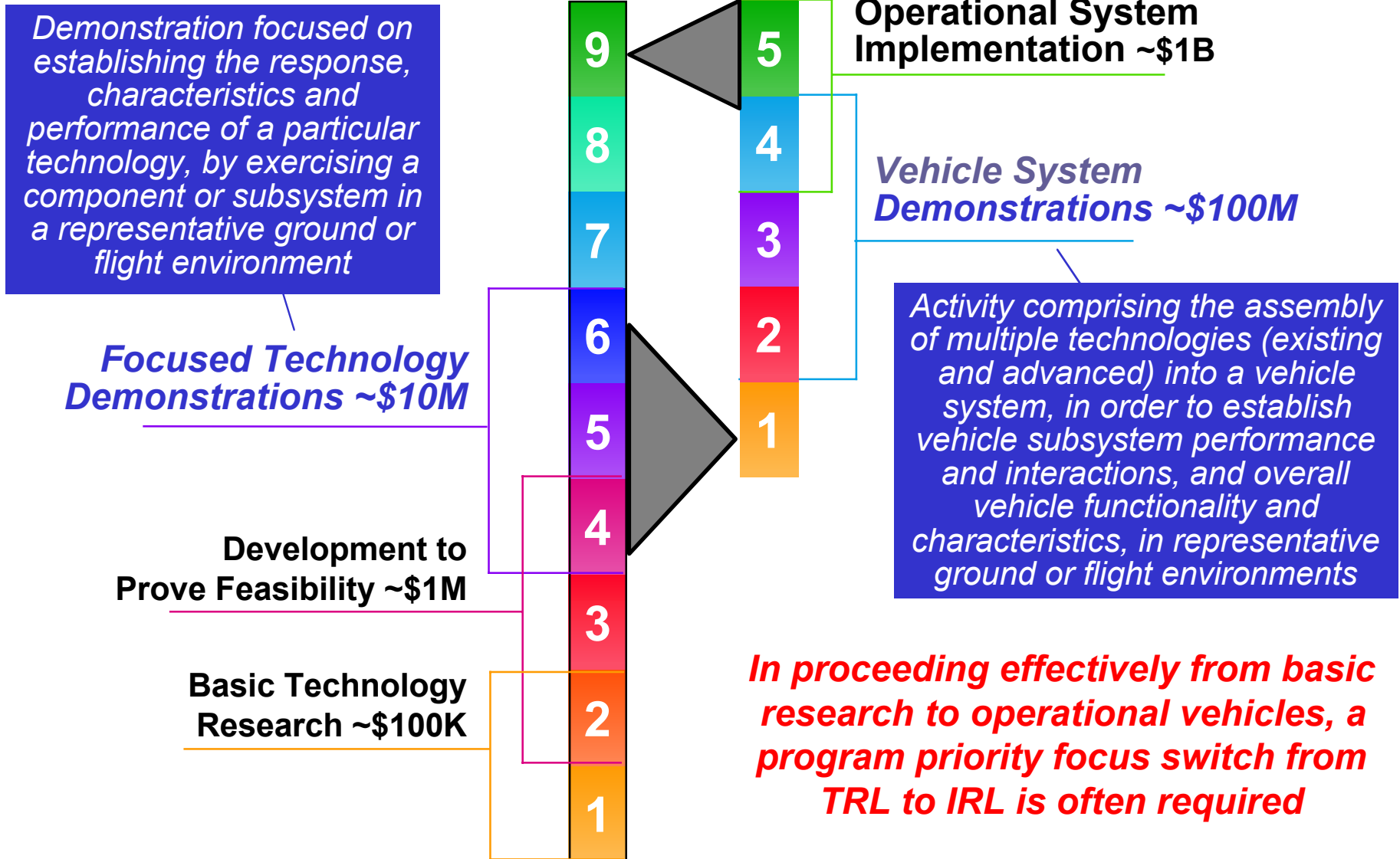
"SEE DISCLAIMER"

# TRL/IRL Relationship



## (Technology Focused) TRL

## IRL (Vehicle Focused)



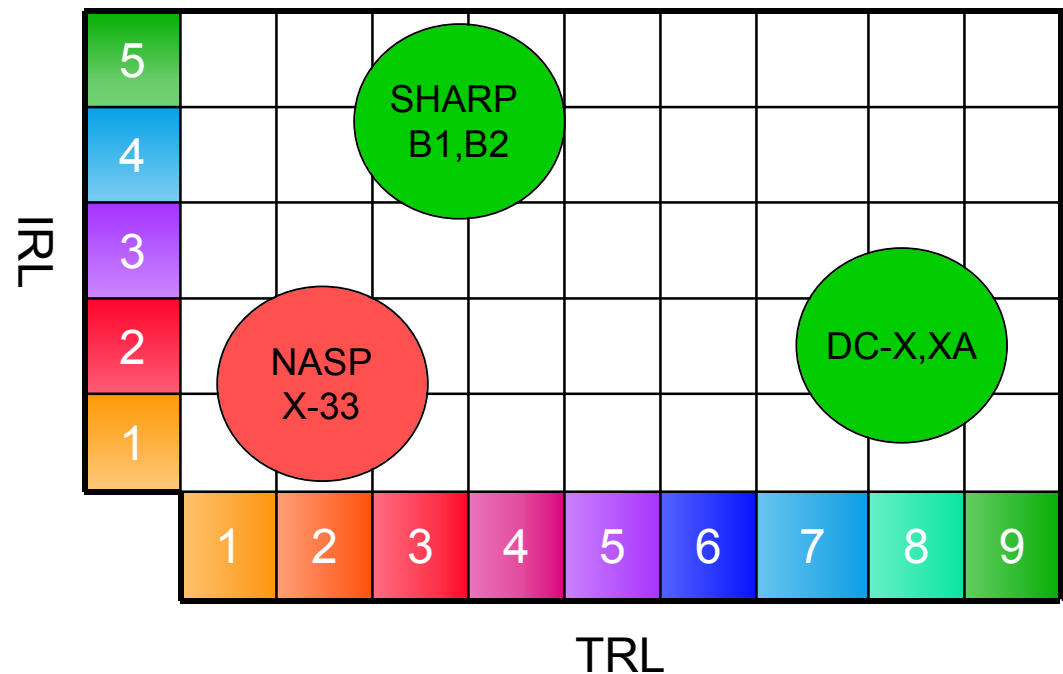


"SEE DISCLAIMER"

# TRL/IRL Historical Patterns



- ◆ Technology demonstrations at low TRL but employed on an existing, high IRL vehicle tend to be successful (SHARP-B1,B2)
- ◆ X-vehicles with overall high TRL and low vehicle IRL tend to be successful (DC-X)
- ◆ X-vehicles or technology demonstrators at overall low TRL and low vehicle IRL tend to fail (NASP, X-33)

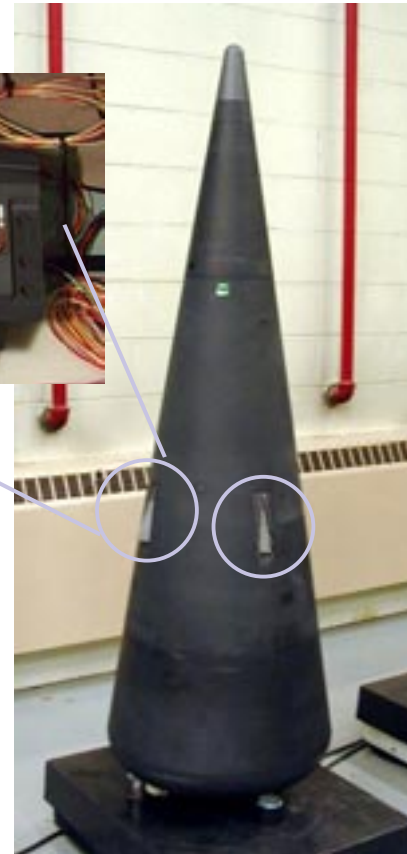


*Note: valid assessments will yield a range of TRL's for any real vehicle system*



"SEE DISCLAIMER"

# SHARP Program Completed to Date (Slender Hypersonic Aerothermodynamic Research Probes)



**SHARP-B2:**  
Successfully completed and flow in 21 months (Sept. 2000 flight)

**Objective:**  
Investigate UHTC sharp leading edge thermostructural performance

**Team:** NASA ARC, MSFC, Sandia, SoRI, USAF, Materials and Machines, Paul Beckman Corp.

SHARP-B1

Re-entry and impact near the Kwajalein Atoll

**SHARP-B1:** Successfully completed in 6 months (May 1997 flight)

**Objective:** Investigate UHTC sharp nosetip thermophysical performance

**Team:** NASA ARC, Sandia, USAF, White Materials, Paul Beckman Corp.

*Sandia's involvement and contributions, and the support of the Air Force, have been key to the success of the SHARP program to date*



# ***Draft Process to Establish Flight Requirements***



- ◆ **Step 1: Establish program requirements, and candidate technologies to meet those requirements**
- ◆ **Step 2: Employ valid TRL and IRL assessments to establish the appropriate phase of development for the different technologies and vehicle concepts**
- ◆ **Step 3: With TRL/IRL assessments, establish appropriate required focused technology or system demonstrations**
- ◆ **Step 4: Employ “Flight Filter” to decide which demonstrations require flight**



# "SEE DISCLAIMER" "Flight Filter"



## ◆ Proposed criteria:

- Technology and/or system requires flight to obtain relevant, or cost effective environments for continued advancement

## Technology Assessment Worksheet

Technology Category	Technology	Description	Applications	Current TRL	Flight Demos Required ? (Y/N)	Justification	If Yes, Focused Technology or Vehicle System Demos	Scale Required	Other Requirements
Advanced Flight	Systems Engineering & Architecture Definition	System engineering and analysis, defining architecture, vehicle concepts, vehicle technologies and operations modes	All advanced vehicle development programs	5	No	Ground activity			
Business/TPS (Reusable, D. Glass)	TPS, Sharp Leading Edges	Small radius ( $r < 10$ mm) leading edges enabling for high L/D reusable vehicles	High L/D Earth to Orbit (ETO) and crew return vehicles, with improved abort and safety. All reentry vehicles	2-4	Yes	Representative combined aerothermal, aerodynamic and natural environments cannot be adequately produced in ground facilities or with analyses	Both	Focused Technology - subscale, depending on technology: System Demos - 50% to 100% scale	Representative re-entry profiles, over Mach 15
	TPS, Operable Acreage	Robust, light weight acreage TPS, with significantly reduced operational repair and maintenance requirements	All new reusable Earth to orbit (ETO) space transportation vehicles	2-4	Yes	Representative combined aerothermal, aerodynamic and natural environments cannot be adequately produced in ground facilities or with analyses	Both	Focused Technology - subscale, depending on technology: System Demos - 50% to 100% scale	Representative re-entry profiles, over Mach 15
	TPS, Operable Joints & Seals	Reliable, robust, light weight joints and seals, with significantly reduced operational repair and maintenance requirements	All new reusable ETO vehicles	3-5	Yes	Representative combined aerothermal, aerodynamic and natural environments cannot be adequately produced in ground facilities or with analyses	Both	Focused Technology - subscale, depending on technology: System Demos - 50% to 100% scale	Representative re-entry profiles, over Mach 15
	Tanks, Reusable Cryo	Reliable, robust, light weight integrated cryotankage, with acceptable operational inspection, repair and maintenance requirements	All new reusable ETO vehicles	3-5	Yes	Representative combined aerothermal, aerodynamic, thermal control and natural environments cannot be adequately produced in ground facilities or with analyses	Both	System: Technology demos can be performed on the ground	Representative ascent, on orbit and re-entry trajectories, with representative tank/structures/TPS interfaces
	Structures, Cold	Advanced composite structures	All new reusable ETO vehicles	4-6	No	Ground demos provide representative environments, with better data quality	Both	50 - 100%	Representative re-entry profiles, over Mach 15
Propulsion (Air/Sea)	Structures, Hot	Advanced hot structure composites, with integrated TPS	Control surfaces, and other special purpose locations on new reusable ETO vehicles	1-4	Yes	Representative combined aerothermal, aerodynamic and natural environments cannot be adequately produced in ground facilities or with analyses	Both	Focused Technology - subscale, depending on technology: System Demos - 50% to 100% scale	Representative re-entry profiles, over Mach 15
	Main Engine, Rocket	New operable main rocket engines, including H <sub>2</sub> /LOX and RP/LOX	All new reusable Earth to orbit (ETO) space transportation vehicles	3-6	No	Ground demos provide representative environments, with better data quality	Both		
	Engine Systems Concepts	Revolutionary concepts that provide 100-1 Thrust/Weight	All new reusable ETO vehicles	1	No	Ground demos provide representative environments, with better data quality	Both		
	Valves & Actuators	Highly reliable, highly reusable, lightweight	All new reusable ETO vehicles	5	No	Ground demos provide representative environments, with better data quality	Both		
	Duct/Lines Thrust Structure	Lightweight, highly integrated, highly reliable, highly reusable, able to handle combustors with high efficiency	All new reusable ETO vehicles	5	No	Ground demos provide representative environments, with better data quality	Both		
	Combustion Devices	Lightweight, highly integrated, highly reliable, highly reusable, multi-combustor - ignitors	All new reusable ETO vehicles	2	No	Ground demos provide representative environments, with better data quality	Both		
	Ignition	Lightweight, highly integrated, highly reliable, highly reusable, multi-combustor - ignitors	All new reusable ETO vehicles	2	No	Ground demos provide representative environments, with better data quality	Both		
	Avionics/Control Sys/IVHM	Highly reliable integrated control and sensor with good system model	All new reusable ETO vehicles	2	No	Ground demos provide representative environments, with better data quality	Both		
	Turbofans	Lightweight, highly integrated, highly reliable, highly reusable, able to handle turbofan	All new reusable ETO vehicles	3	No	Ground demos provide representative environments, with better data quality	Both		
	Main Engine, Air/Sea	New operable, light weight engines, including H <sub>2</sub> /LOX and RP/LOX	Selected new reusable ETO vehicles	1-4	Yes	Representative variable aerodynamic/aerothermal cannot be simulated by ground test facilities	Both	TBD	Representative ascent trajectories
	Recovery Systems	Lightweight, highly integrated new and duct that might also provide thrust structure	All new reusable ETO vehicles	TBD	No	Ground demos provide representative environments, with better data quality	Both		
Operations (Risk)	Recovery Systems	Recover the vehicle (parachute, airbag, float, crane, etc.)	All new reusable ETO vehicles	3-6	Yes	High technology response and reliability demonstrations	Both	Full	
	Crew Systems	Hardware for human interfaces and life support	All new crewed ETO vehicles	2-5	No	Ground simulations are adequate for development	Both	Full	
	Vehicle Turnaround	Advanced checkout, repair and re-certification activities on the RV	All new ETO vehicles	2-5	Yes	Full mission environments needed to demonstrate new technologies	System	Subscale	
	Range & Flight Ops	Advanced range safety and flight operations management	All new ETO vehicles	2-5	Yes	Full mission environments needed to demonstrate new technologies	System	Subscale	
	Crew Ops	Operations to support crew flight activities	All new crewed ETO vehicles	3-6	No	Ground simulations are adequate for development	System	Subscale	

## Initial Flight Requirement Summary

Technology	Current TRL	Focused Technology Flight Demos Required	Vehicle System Flight Demos Required	Comments
<b>Structures/TPS</b>				
Sharp Leading Edges	2-4	Yes	Yes	Requires flight for full mission environments
Operable Acreage TPS	2-4	Yes	Yes	Requires flight for full mission environments
Operable Joints and Seals	3-5	Yes	Yes	Requires flight for full mission environments
Tanks, Reusable Cryo	3-5	No	Yes	System level demo in full mission environment required
Hot Structures	1-4	Yes	Yes	Requires flight for full mission environments
<b>Propulsion</b>				
Main Engine, Air/Sea	1-4	Yes	Yes	Requires flight for full mission environments
In-Flight Fluid Transfer	3-5	No	Yes	System level demo in full mission environment required
Vehicle Separation	4-6	No	Yes	System level demo in full mission environment required
<b>Software</b>				
IVHM	2-6	Yes	Yes	Requires flight for full mission environments
Automated GN&C	3-6	Yes	Yes	Requires flight for full mission environments
Communications	4-6	No	Yes	System level demo in full mission environment required
<b>Subsystems</b>				
Actuators	3-5	Yes	Yes	Requires flight for full mission environments
Crew Escape	2-5	No	Yes	System level demo in full mission environment required
<b>Operations</b>				
Vehicle Turnaround	2-5	No	Yes	System level demo in full mission environment required
Range Safety & Flight Management	2-5	No	Yes	System level demo in full mission environment required



# ***Interim Conclusions***



## **◆ Phased Risk Approach provides multiple advantages**

- Spreads risk across multiple program phases, improving chances of successfully completing the different phases, and helping to restrain attempting too many things in any particular phase
- Provides sequenced opportunities to harvest the most attractive and mature technologies (efficiently narrowing the technology field) when proceeding from one phase to the next
- Highlights the critical need for system integration, in addition to technology development, and provides a clear demarcation for program priority focus shift from technology development to vehicle integration
- Provides multiple product cycles, which are key for effective technology development
  - E.g., the computer industry has 18 month product cycles, with factor of 2 improvement targets
  - Product cycles are critical for obtaining and maintaining a knowledgeable and motivated workforce, and overall organizational competence

## **◆ System Analysis should underpin technology development selections at each development step**

- Selections for any demos should require significant impact on future operational vehicles - as shown/verified by systems analysis
- System analysis should include assessment of technical and programmatic risks, as well as identifying technology off ramps



*"SEE DISCLAIMER"*

## ***Interim Conclusions (Cont.)***



### **◆ Importance of Technology Demos often overlooked**

- Provide critical technology maturation and product cycles to help ensure success of System Demos
- Much lower cost than System Demos - ~\$10M compared to ~\$100M for System Demos
- Flight demos can often be flown in a "piggy back" mode on operational vehicles - e.g., SHARP - greatly reducing risk of flight failures

### **◆ System Demos should be employed judiciously**

- High cost and visibility of flight demos make the price of failure high as well
- Strongly consider ground demos (IRL 3) where possible, before pursuing flight demos (IRL 4)
- Proceed with flight demos only when all flight critical technologies are adequately mature (TRL 5 or above), or employ more mature technologies

# Task1

# X-Vehicle Lessons Learned

by  
*Curtis McNeal*

*Marshall Space Flight Center*  
Huntsville, Ala. 35812  
[curtis.mcneal@msfc.nasa.gov](mailto:curtis.mcneal@msfc.nasa.gov)  
(256) 544-8538



## DISCLAIMER

The interim study results presented herein are provided to industry and other interested parties for consideration in preparation of proposals for future government x-vehicle programs. This is an interim report and reflects NASA's current evaluation of x-vehicle programs. A final report will follow the conclusion of the study. Nothing presented herein in any way alters the content or requirements of any ongoing procurement.

- ◆ **Collect lessons learned from successful and unsuccessful X-Vehicle programs conducted by DoD and NASA during the 1990s.**
- ◆ **Evaluate data to determine broad/cross cutting reasons for success.**
- ◆ **Propose guidelines that will promote successful future NASA X-Vehicle Programs.**





*"SEE DISCLAIMER"*  
**Approach**



## **1) Contact program managers for recent X-Vehicle Programs and request their assistance in study**

- DC-X            Jess Sponable (Data received)
- DC-XA        Dan Dumbacher (Data received)
- X-33            Dan Dumbacher (Data received)
- X-34            Mark Fisher (Data received)
- X-36            Gary B. Cosentino (Data received)
- X-37            Dick Cervisi (Data received)
- X-38            John Muratore
- X-40            Dick Cervisi (Data received)
- X-40A        Dan Mitchell (Data received)
- X-43A-LS    Chuck McClinton



*"SEE DISCLAIMER"*

## ***Approach (Cont.)***



- 2) Request lessons learned from each program**
- 3) Collate data into single document**
- 4) Evaluate data to identify broad/cross cutting reasons for success**
- 5) Propose guidelines for future program success**
- 6) Get concurrence from past X-Vehicles program managers on guidelines**
- 7) Final products**
  - Guidelines for Future X-Vehicle Program Success
  - An Appendix containing lessons learned from each program



*"SEE DISCLAIMER"*

# ***Traditional X-Vehicle Programs***



- ◆ **Early X-Vehicles created to “expand the flight envelope”**
- ◆ **Early envelope expansion aimed at higher and faster**
  - X-1 through X-15
  - 1950s through 1960s
- ◆ **Later Expansion efforts turned to other measures of flight performance**
  - Turn-radius
  - Time to climb
  - Sustained cruise mach number
  - Agility
  - Stealth
  - 1970s through 1990s

*Interim Results*



*"SEE DISCLAIMER"*

# ***Space Related X-Vehicles***



- ◆ **Higher, faster, shorter transit times no longer the figure of merit**
- ◆ **Mission cost became the dominant factor in the 1990s**
- ◆ **Safety and reliability have become the dominant factors in the new millennium**
- ◆ **Only the application of new technologies to new flight vehicles will move us from the current SOTA to a new operating capability**
- ◆ **Air Force and NASA have initiated a number of X-Vehicles to demonstrate the required technologies**
  - DC-X, DC-XA, X-33, X-34, X-37, X-38, X-40, X-40A
- ◆ **Each of these is an attempt to expand the technology envelope**

*Interim Results*

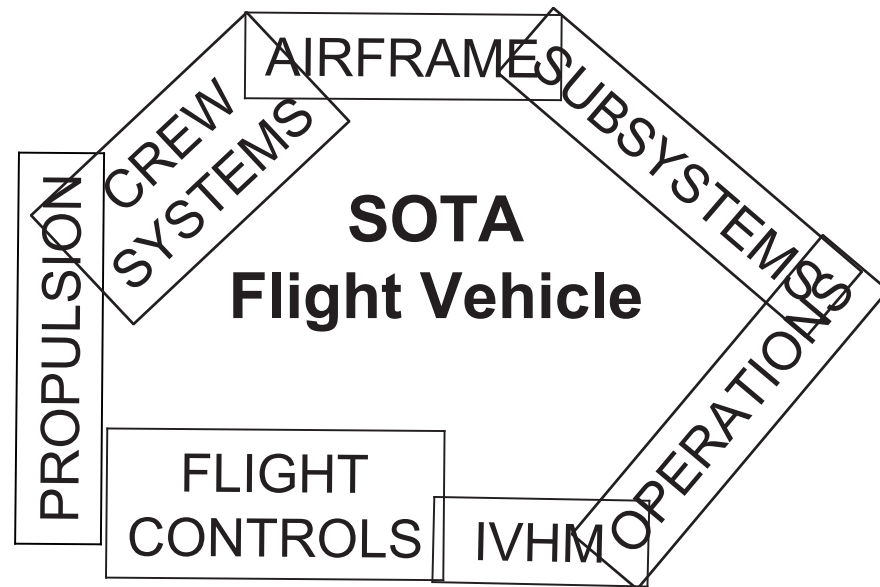


*"SEE DISCLAIMER"*  
**Performance Envelope Replaced by  
The Technology Envelope**



**2ND GEN RLV  
TECHNOLOGIES**

TA2-AIRFRAME  
TA3-SUBSYSTEMS  
TA4-OPERATIONS  
TA5-IVHM  
TA6/8-PROPULSION  
TA7-FLIGHT CONTROLS  
TA9-CREW SYSTEMS



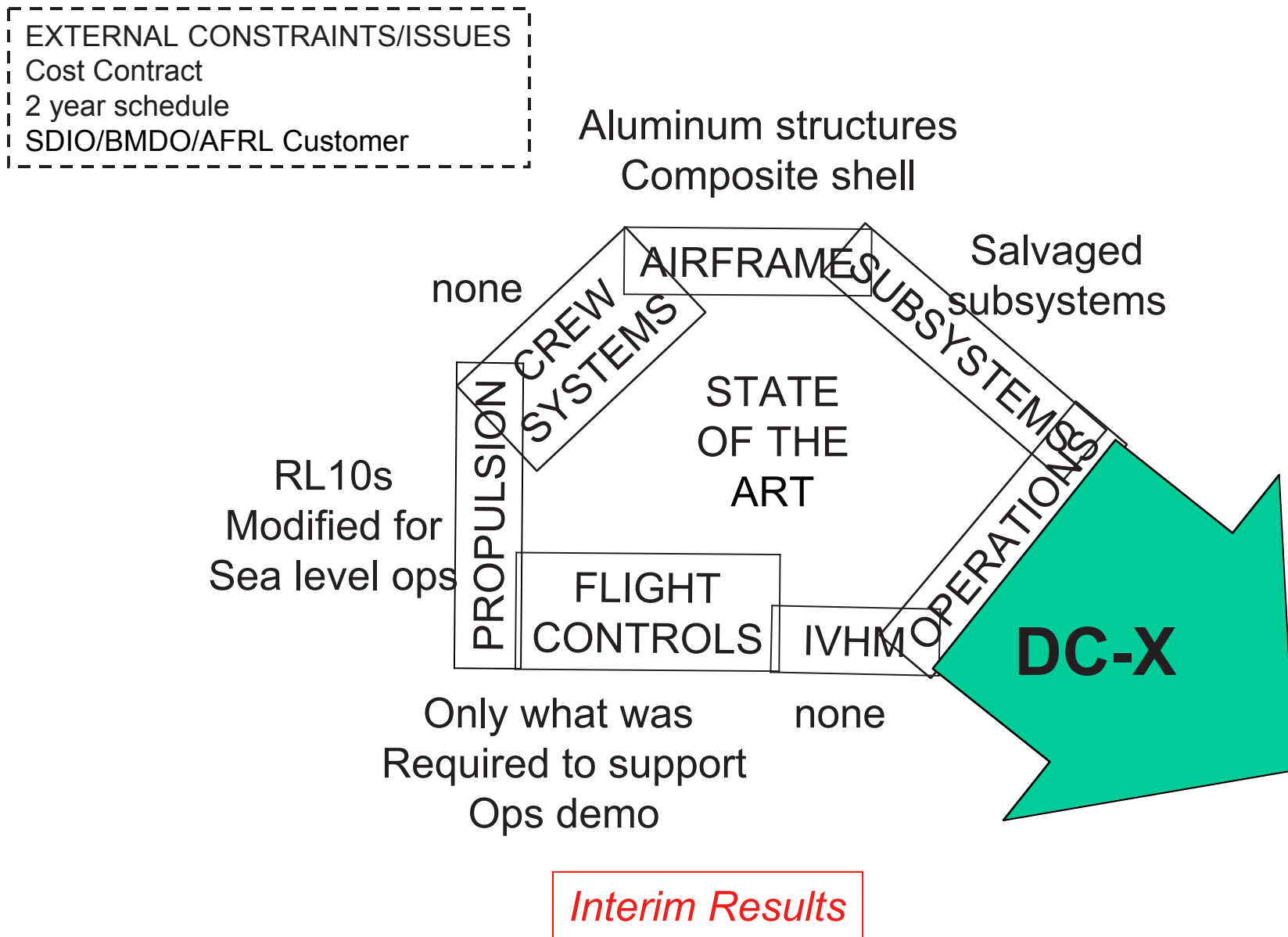
*Interim Results*



"SEE DISCLAIMER"



# DC-X "The Operations Demonstrator"



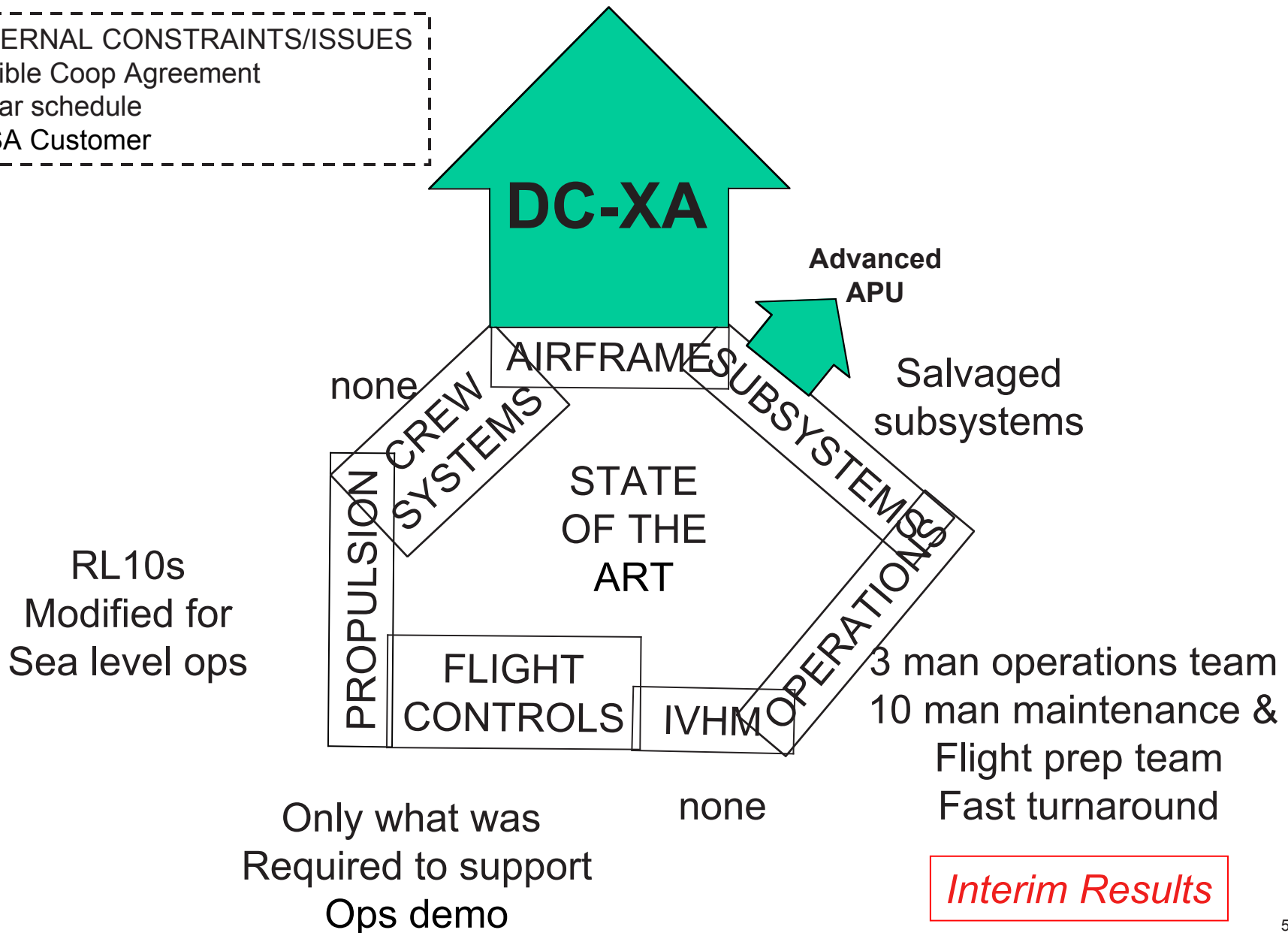


"SEE DISCLAIMER"

# DC-XA "NASA's First Space Related X Vehicle"



EXTERNAL CONSTRAINTS/ISSUES  
Flexible Coop Agreement  
2 year schedule  
NASA Customer

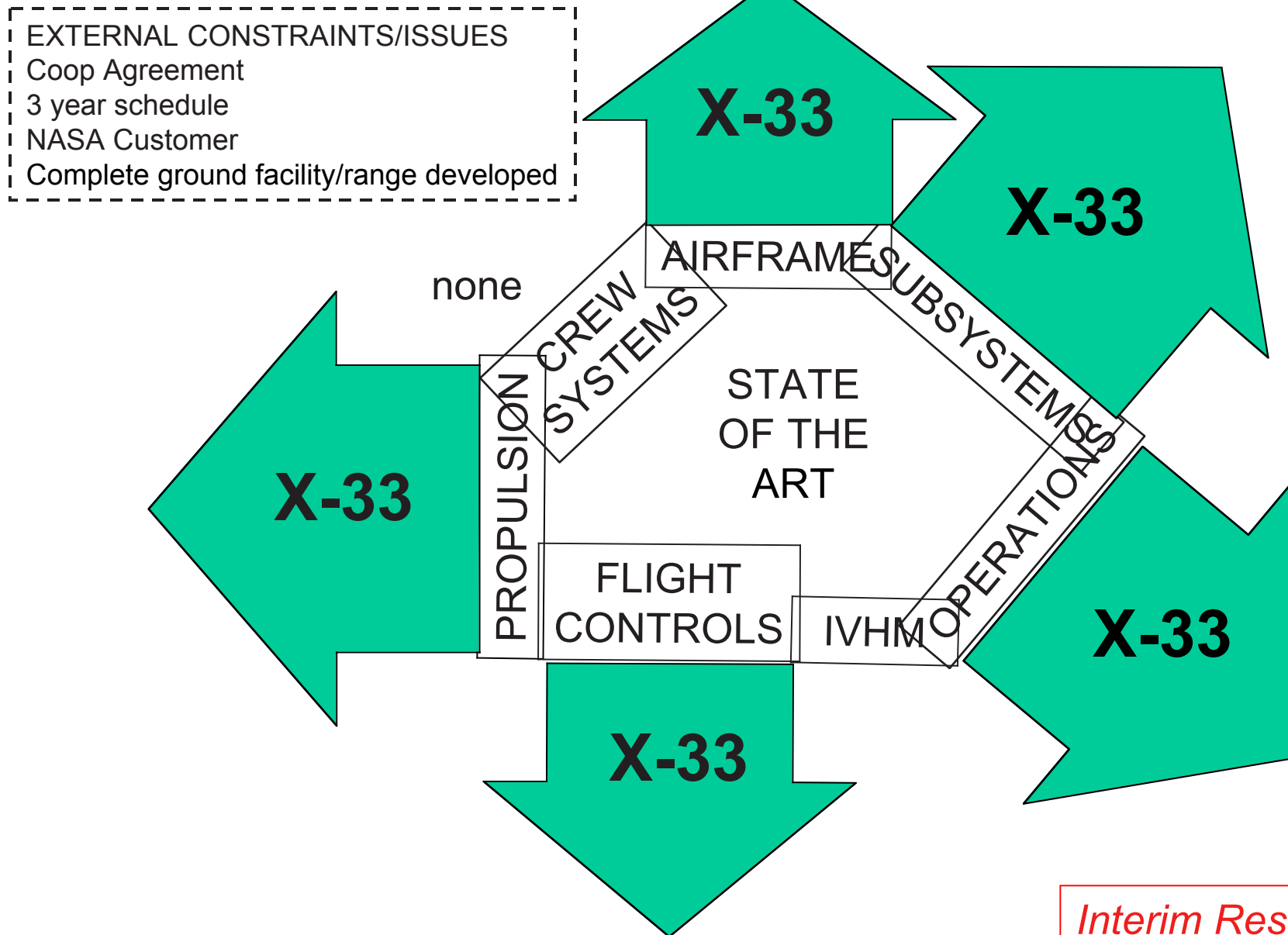




"SEE DISCLAIMER"



# X-33 "NASA's Precursor to SSTO Operations"



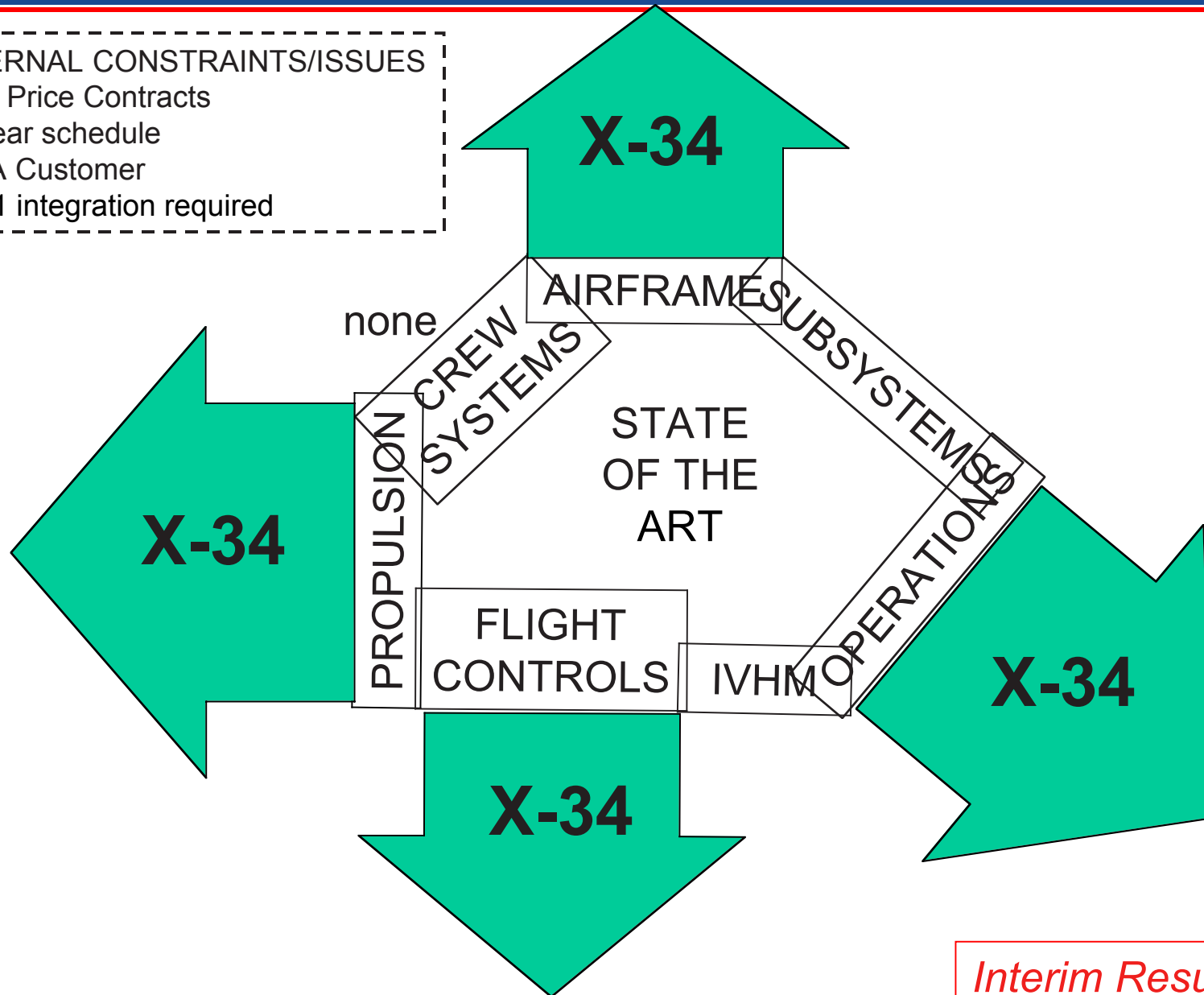


"SEE DISCLAIMER"



## X-34 "NASA's Technology Bridge to the X-33"

EXTERNAL CONSTRAINTS/ISSUES  
Fixed Price Contracts  
2.5 year schedule  
NASA Customer  
L1011 integration required

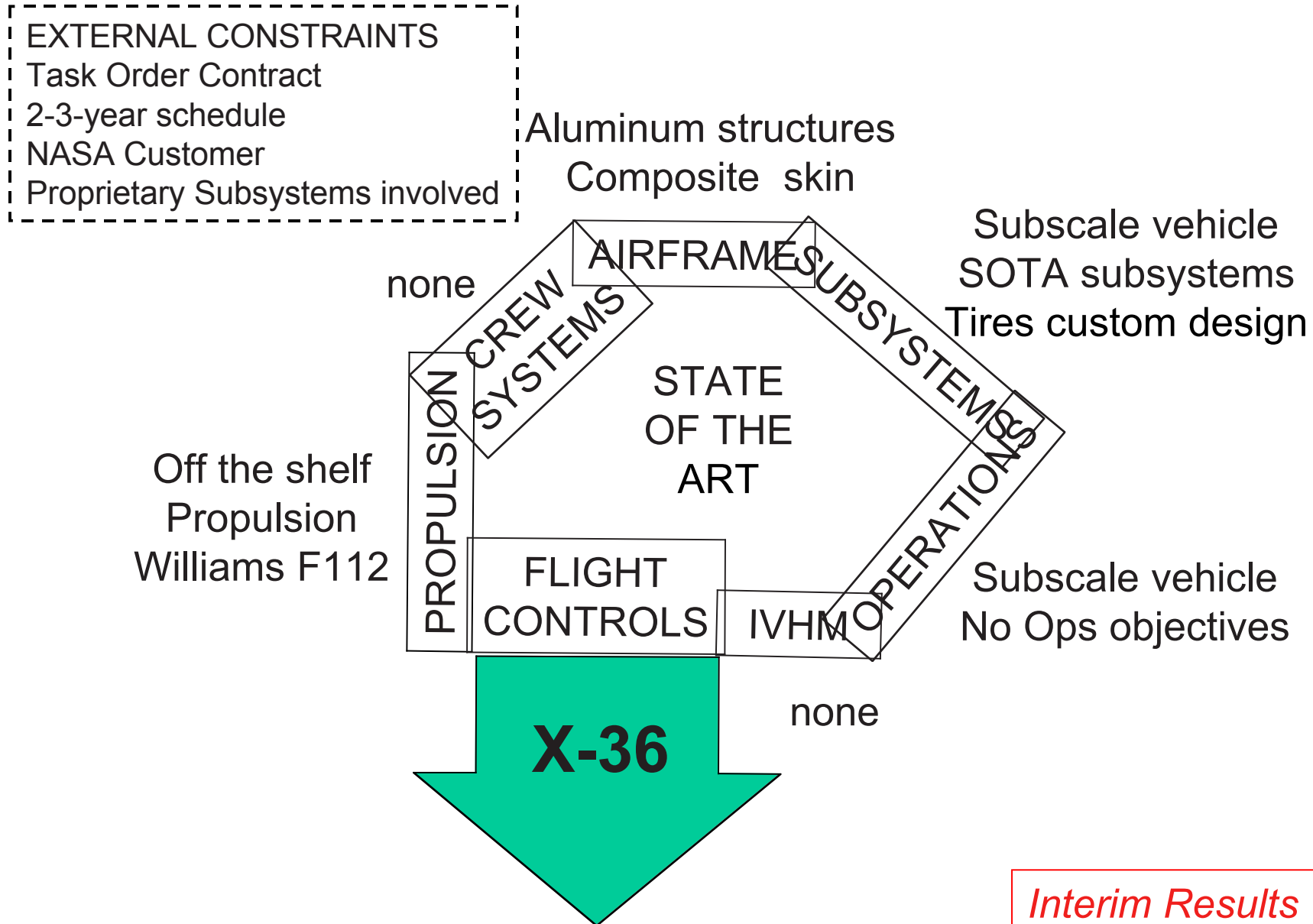


*Interim Results*



"SEE DISCLAIMER"

# X-36 NASA's "Tail-less Fighter" Demonstration



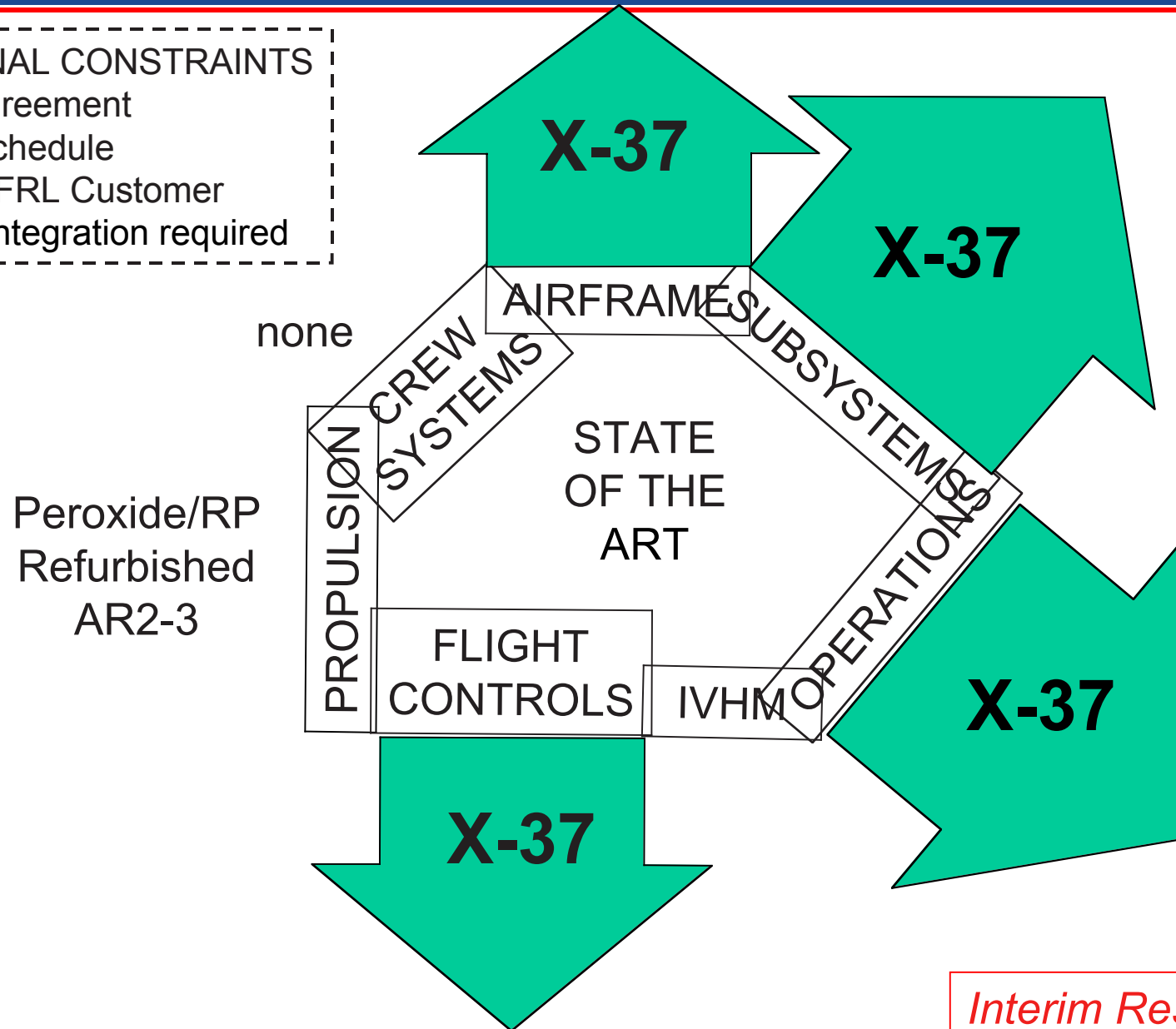


"SEE DISCLAIMER"



# X-37 "The First of NASA's New Era of X Vehicles"

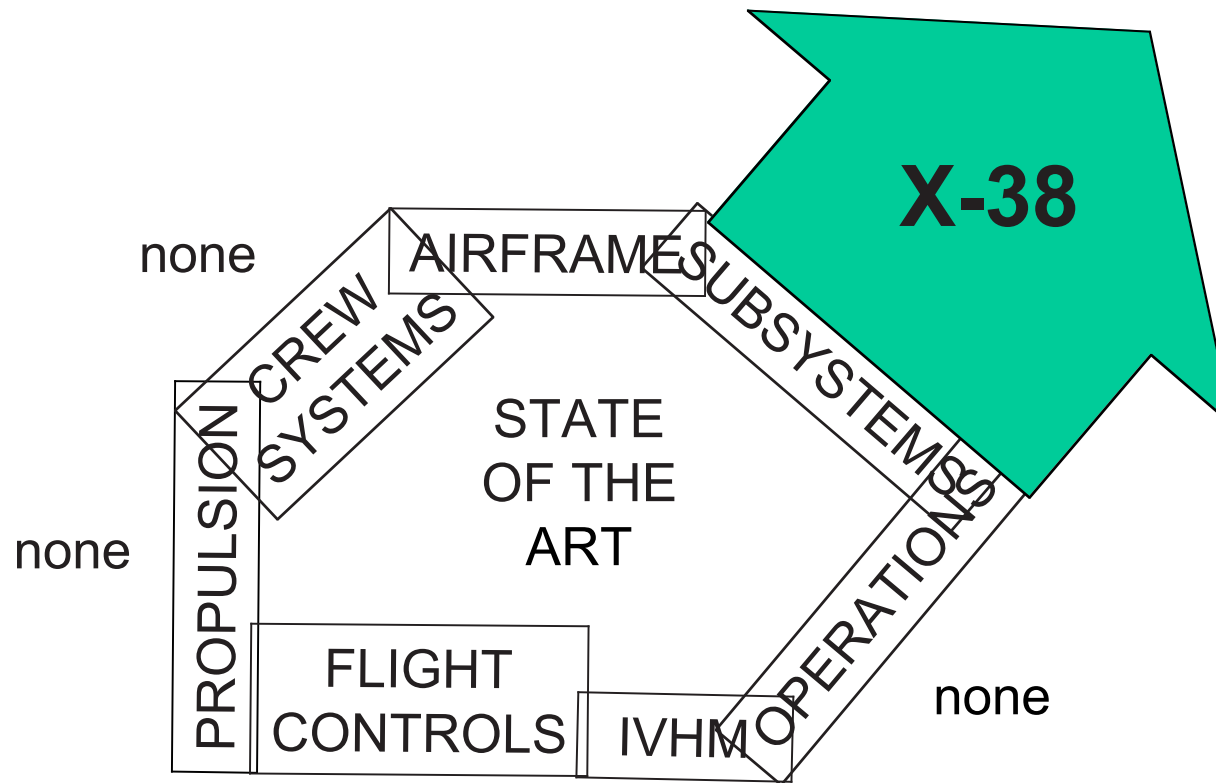
EXTERNAL CONSTRAINTS  
Coop Agreement  
3 year schedule  
NASA/AFRL Customer  
Shuttle integration required



*Interim Results*



*"SEE DISCLAIMER"*  
**X-38 NASA's "Crew Return  
Landing System Demonstrator"**



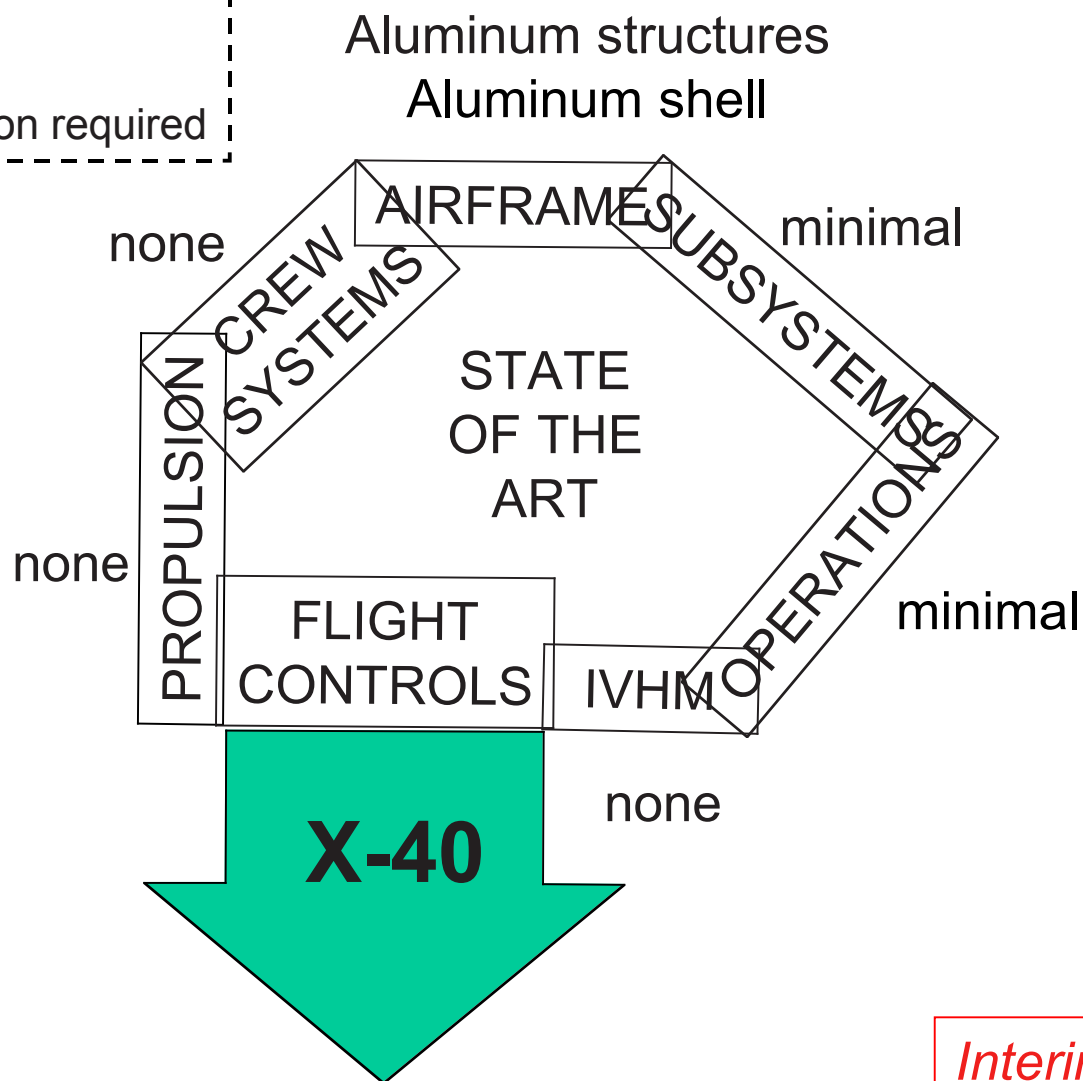
*Interim Results*



"SEE DISCLAIMER"  
**X-40 AFRL's**  
**"Autonomous Landing Demonstrator"**



EXTERNAL CONSTRAINTS  
Task Order Contract  
2-year schedule  
AFRL Customer  
Helicopter integration required



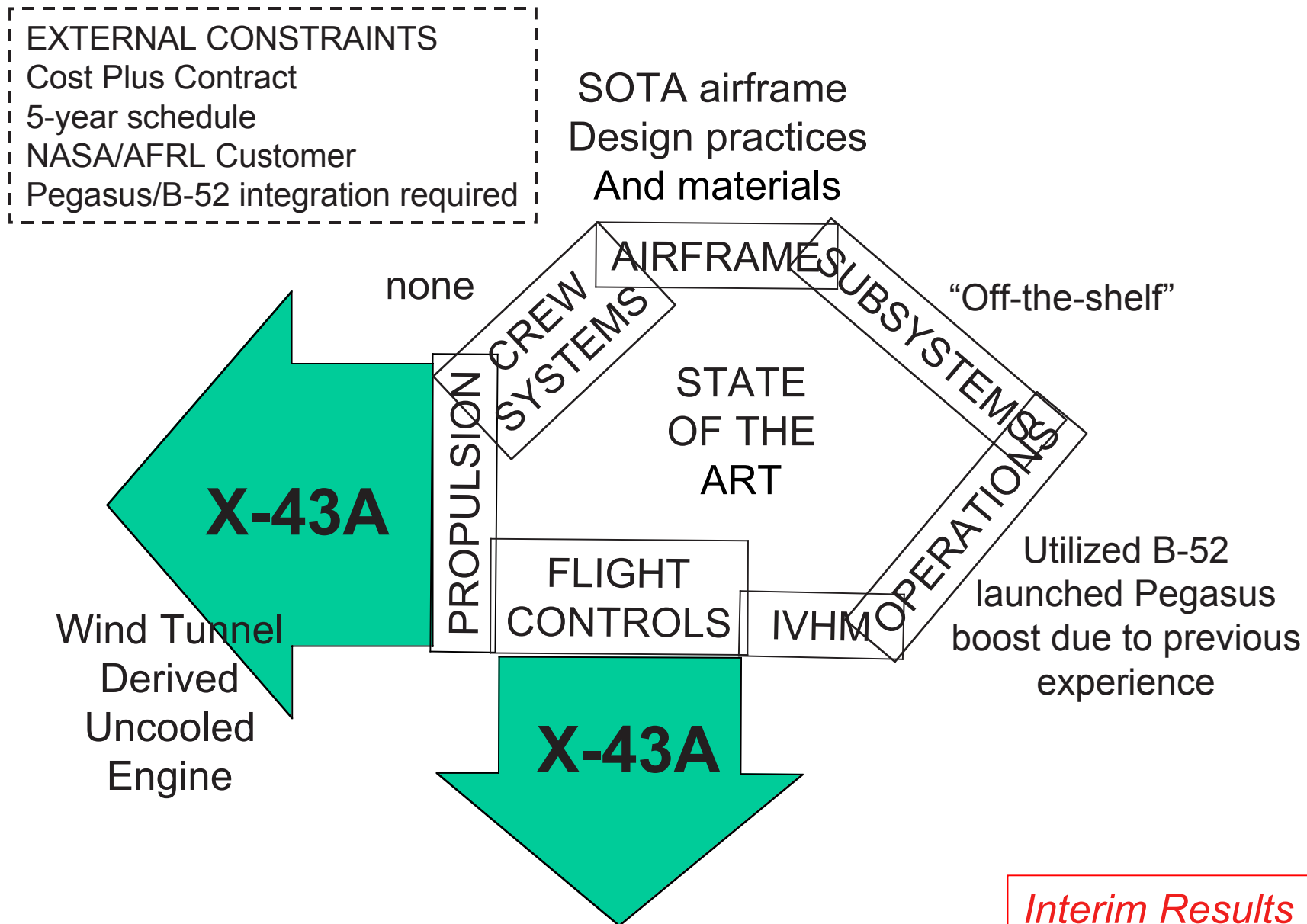
*Interim Results*



"SEE DISCLAIMER"

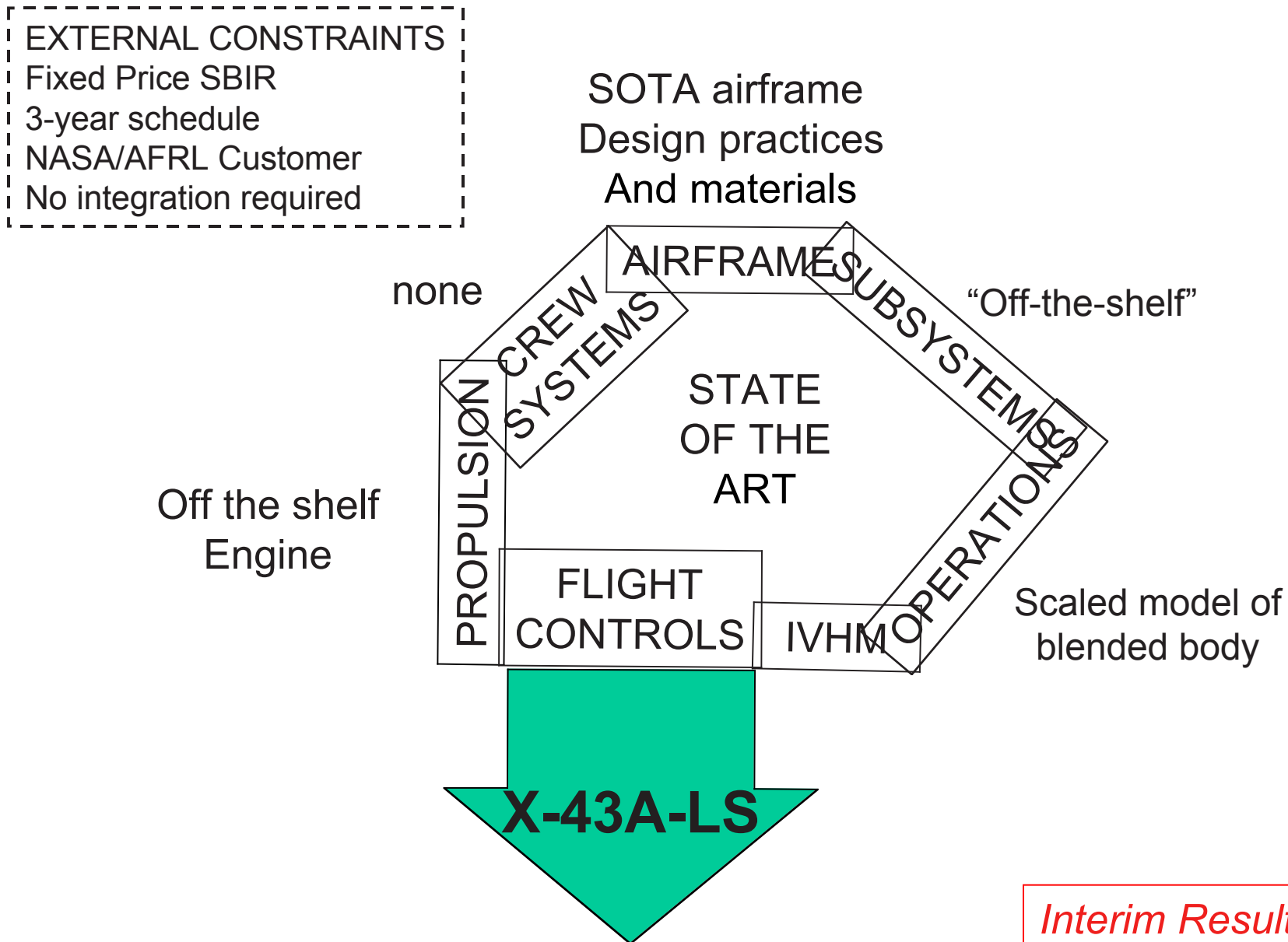
**X-43A**

# "NASA's Hypersonic Research Vehicle"





"SEE DISCLAIMER"  
**X-43A-LS "NASA's Low Speed  
Blended Body Research Vehicle"**



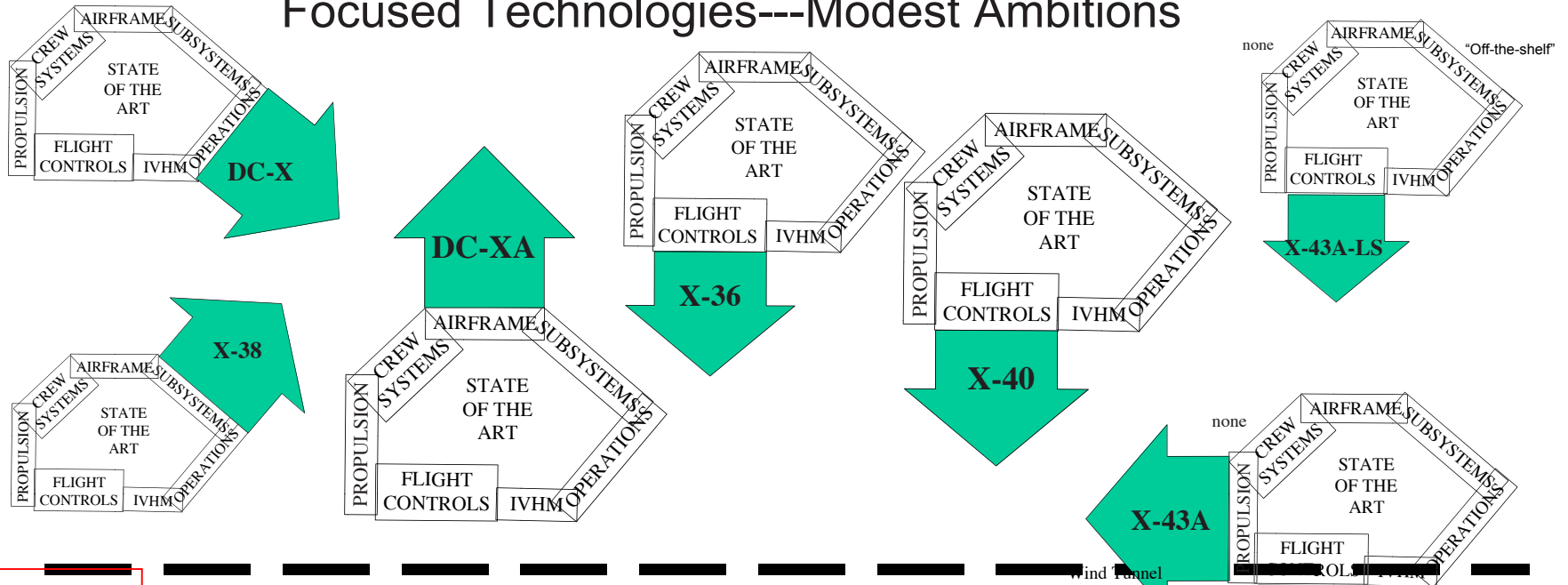


"SEE DISCLAIMER"



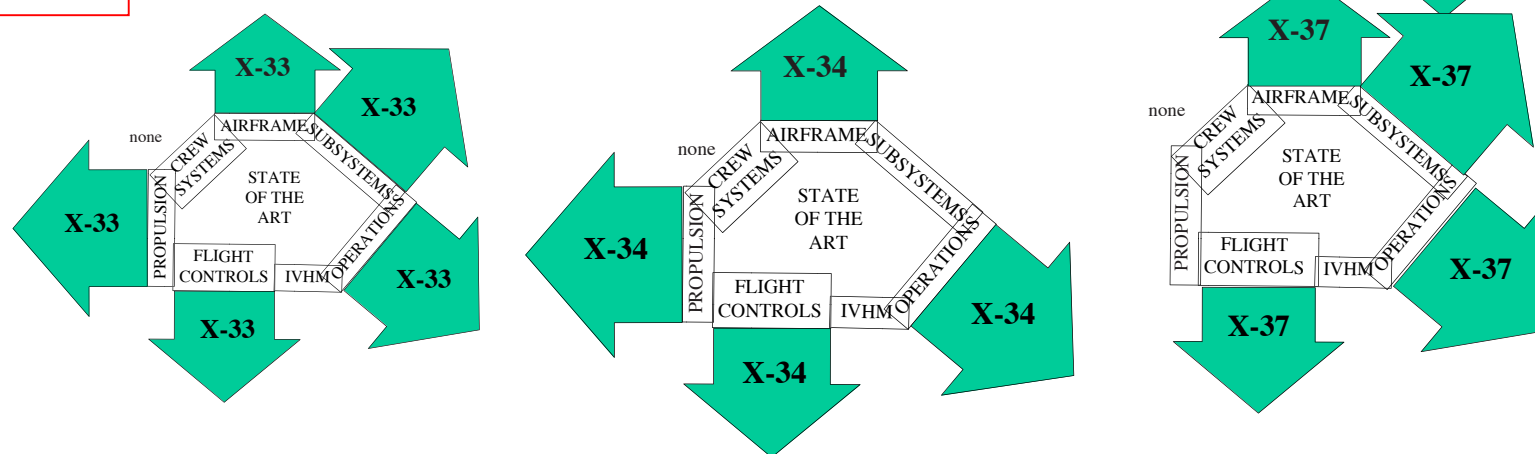
# Two Tiers of X-Vehicles Emerge

## Focused Technologies---Modest Ambitions



*Interim Results*

## Multiple Technologies---Ambitious



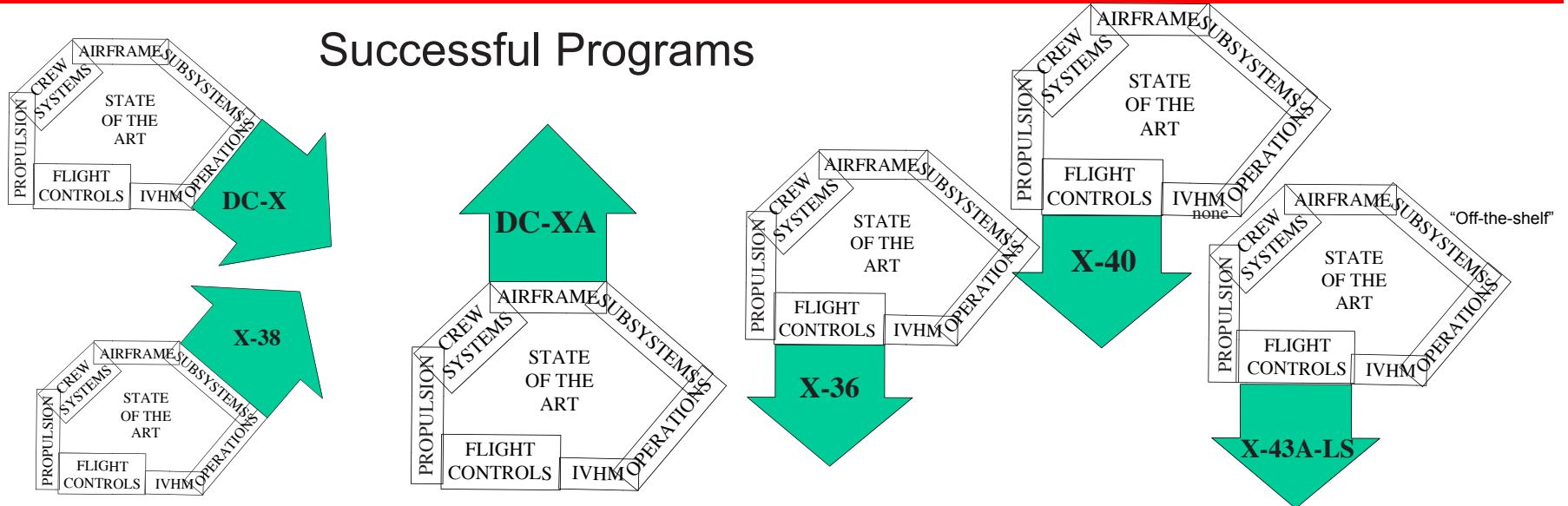


"SEE DISCLAIMER"

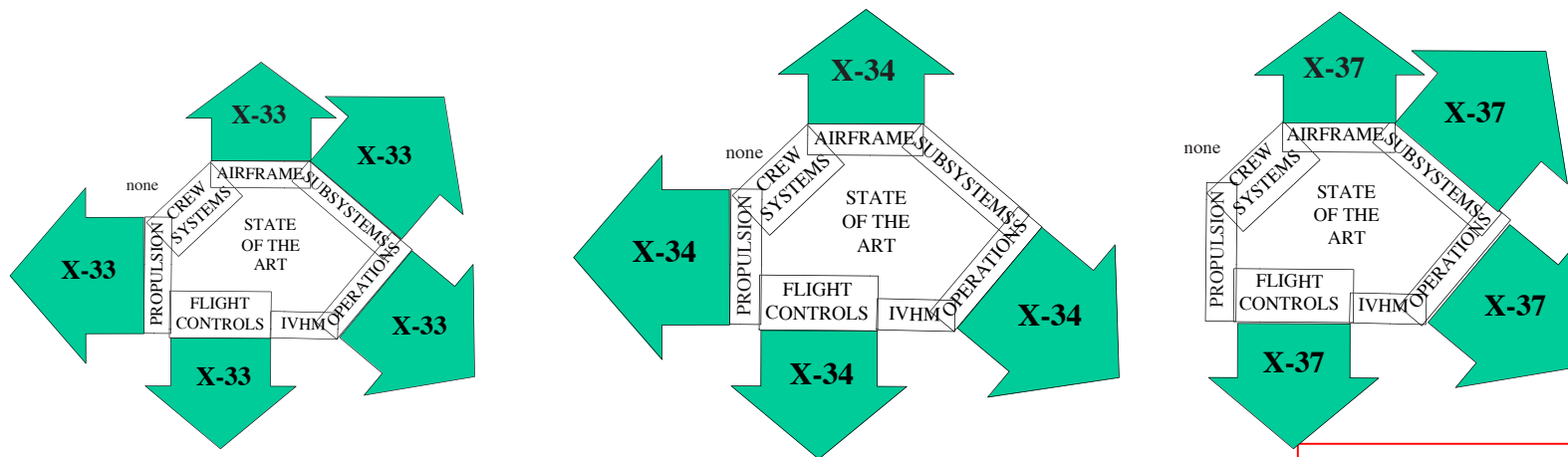
# Two Tiers of X-Vehicles Emerge



## Successful Programs



## Other Programs



*Interim Results*



"SEE DISCLAIMER"

# ***X-Vehicle Guidelines (1&2)***



## **1) X-Vehicles should have a focused technology thrust**

- All other technologies incorporated into the air vehicle should be SOTA or less. All other technologies should represent little or no risk to successful program performance

## **2) Modification of, or scale up from, existing vehicles substantially lowers risk**

- DC-X → DC-XA
- X-24 → X-38
- X-40 → X-40A
- X-40A → X-37 ALTV (De-scoped)

*Interim Results*



"SEE DISCLAIMER"

## ***X-Vehicle Cost Growth***



- ◆ **Cost growth ranged from -10% on DC-XA to over 100%**
- ◆ **Average of data available is 46% cost growth**

*Interim Results*



*"SEE DISCLAIMER"*

# ***X-Vehicle Guidelines (1-3)***



- 1) X-Vehicles should have a focused technology thrust**
- 2) Modification of, or scale up from, existing vehicles substantially lowers risk**
- 3) X-Vehicles require robust reserves**
  - Industry's estimating tools are ill suited to one of a kind X-vehicles
  - Competitive source selection biases estimates downward
  - Competitive negotiations biases contract values downward
  - Program reserves must be adequate to cover these realities

*Interim Results*



"SEE DISCLAIMER"

# X-Vehicle Contracting



Program	Contract Mechanism	Contract/Customer Environment
DC-X	Cost Plus Zero Fee	Cooperative & Flexible
DC-XA	3 Cooperative Agreements	Cooperative & Flexible
X-33	1 Cooperative Agreement	---
X-34	Fixed Price Contract	---
X-36	Task Order Contract	Very Flexible
X-37	1 Cooperative Agreement	---
X-40	Task Order Contract	Flexible/Hands Off Customer
X-43A-LS	Fixed Price SBIR	---
X-43A	Cost Contract	---

*Interim Results*



"SEE DISCLAIMER"

# ***X-Vehicle Guidelines (1-4)***



- 1) X-Vehicles should have a focused technology thrust**
- 2) Modification of, or scale up from, existing vehicles substantially lowers risk**
- 3) X-Vehicles require robust reserves**
- 4) The contracting mechanism and environment must be flexible**
  - It is an invalid assumption that everything can be identified and negotiated at contract initiation
  - Both the government and industry partner must be willing to make changes at appropriate times throughout the program life
    - Contractor should not be rewarded for poor performance
    - Contractor should not bear all of the cost risk

*Interim Results*



*"SEE DISCLAIMER"*

# ***The "Right" Government Role***



- ◆ **Flight demonstration programs have three primary phases**
  - Program Initiation/Requirements Generation (ATP-SRR-PDR)
  - Program Execution
  - Flight Demonstration
- ◆ **The government's role in Program Initiation**
  - Paramount responsibility for requirements generation/approval
  - Significant participation in program planning
    - Determining support role for the government
    - Establishing resources expenditure plan
    - Establishing key program milestones/technical performance measures
- ◆ **The government's role in Program Execution**
  - Insight into program's progress
  - Support of the program through application of government unique tools, facilities, and expertise
- ◆ **The government's role in the Flight Demonstration**
  - Safety is number one---liability usually passes to the government
    - Personnel
    - High Value and Unique Facilities at test ranges
    - Safety of the flight article---because we have a large investment in it
  - Support of the program through application of government unique tools, facilities, and expertise
  - Insight into program's progress

***Interim Results***



*"SEE DISCLAIMER"*

# ***X-Vehicle Guidelines (1-5)***



- 1) X-Vehicles should have a focused technology thrust**
- 2) Modification of, or scale up from, existing vehicles substantially lowers risk**
- 3) X-Vehicles require robust reserves**
- 4) The contracting mechanism and environment must be flexible**
- 5) The government must perform the "Right" Role**

*Interim Results*



*"SEE DISCLAIMER"*

## ***Closing Information***



- ◆ **The CBD announcement of this briefing will be appended to provide details on how to obtain a copy of today's presentation**
- ◆ **Final Report expected in April 2002**
- ◆ **A CBD announcement will provide information on how to obtain a copy of the Final Report**

### **DISCLAIMER**

The interim study results presented herein are provided to industry and other interested parties for consideration in preparation of proposals for future government x-vehicle programs. This is an interim report and reflects NASA's current evaluation of x-vehicle programs. A final report will follow the conclusion of the study. Nothing presented herein in any way alters the content or requirements of any ongoing procurement.